Conserving Corn Belt Soil

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Contents

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FIGURE 1.—From half to two-thirds of the world's corn crop is grown in the United States.

Seventy Crop Years

FOR SEVEN DECADES the Corn Belt has demonstrated its productiveness. Early settlers nosed their plowshares into incredibly rich soil. Experience helped to crystallize the early belief that the soil would always be productive. Older farmers coming from the East in the foretide of settlement, shook their heads dubiously at the idea of cropping the same land year after year to the one crop, corn. But year after year abundant yields swayed all but the most conservative toward the conviction that here was cornland that could not be worn out.

Even when men learned that the productiveness of the Corn Belt could be impaired, what did it matter? A virgin farm farther west was calling. Some, it is true, attached themselves with feeling and permanence to the soil; but many others became restless and could not resist the westward call.

Superficially considered, crop yields in the Corn Belt give little cause for apprehension (fig. 1). If the annual average yield of corn from 1866 to 1929, over 60 years, is compared with that for the decade 1920 to 1929 very little increase or decrease is noted. Ohio farmers gained but 1 bushel over this long period; Indiana farmers gained about 1½ bushels; Illinois farmers a little over 2 bushels, and Iowa farmers about 3. Slight losses appear for the corn growers of Missouri, Kansas, and Nebraska. Yields of other crops show a similar trend.

The fact that yields held up during this period has given comfort to some scientists and farmers who consider erosion only a natural process: "That is the way we got our soil in the first place." Erosion is, indeed, a natural process; but on many of our richest Corn Belt lands, as elsewhere, it has been proceeding at an unnatural, accelerated, almost catastrophic rate.

And consider this: What would be the average yield of corn per acre today in the Corn Belt if the soil was as productive as it was in 1880 and improved practices were in use to the same extent that they are now? Or, to put a similar question in a different way: What would be the average corn yield today if farmers attempted to farm as our ancestors did in 1880?

Since 1880 the Corn Belt has witnessed the widespread adoption of improved agricultural practices. Even on the farms most poorly managed many practices are followed that were unavailable to farmers of a generation ago. And on the better-managed farms, where more of the improved practices are employed, yields are as high as or in many cases slightly higher than those obtained by old-time farmers. Yet, in spite of more underdrainage, improved plant varieties, more legumes in the crop rotation, improved machinery, better control of pests and diseases, fertilizers, abandonment of worn land for new; despite all of these, the average acre yields do not rise perceptibly (fig. 2).

Agronomists R. M. Salter, R. D. Lewis, and J. A. Slipher, of Ohio State University, deal with this problem of yields with unusual clarity in a recent Ohio bulletin entitled "Our Heritage—the Soil." After listing and commenting on the measures which should have given large yield increases in Ohio, they make this significant observation:

> Certainly, taken together, all of these changes and improvements should have raised acre yields considerably—how much, it is difficult to say exactly, but we believe an increase of 40 to 60 percent would have been conservative.
>
> For example, wheat yields were only 3.2 bushels more during the decade of 1920–1929 than in the seventies. Four-fifths of Ohio's wheat acreage is now planted to improved varieties which yield, according to hundreds of field tests and thousands of threshermen's records, 3 or 4 bushels more per acre than the varieties they displaced. From 1920 to 1929, the average acre of wheat in Ohio annually received about 180 pounds of fertilizer, and we know from hundreds of field tests

Figure 2.—Despite the use of improved agricultural practices, average acre crop yields do not rise perceptibly.

that this alone should have increased the yield at least 7 bushels. Taken together, fertilizers and better varieties should have increased the yield 10 bushels, as against an actual increase of only 3 bushels.

Furthermore, since the seventies, the bulk of the Ohio wheat acreage has shifted from the older settled section of the southeast to newer lands in the western part of the State. The agronomists conclude:

> There can be but one explanation for the stubbornness with which acre yields have resisted the farmer's efforts to improve them. *The natural productive capacity of the land has been deteriorating at a rate almost fast enough to offset all of these improvements in soil and crop management.* With every step ahead we have slipped back almost if not quite as far.

One reason, at least, for declining productivity can be found in our mistaken belief that the soil itself—"sure and firm set earth"—is permanent. Until quite recently, we have looked upon the soil as something like a storehouse or bank in which were deposited slowly soluble plant nutrients. There was no problem of soil fertility, it was generally thought, so long as plants were not permitted to overdraw this fund. If the fund of plant nutrients became low it was assumed that it was only necessary to replenish the supply through legumes and commercial fertilizers. This concept is partly right; but it is incomplete. We know now, tardily, that the storehouse, the soil itself, can be and on many farms is being removed swiftly by erosion. The bank building is often being swept away along with the deposits.

At the close of a 70-crop-year span, this publication attempts to show the cause and extent of erosion in the Corn Belt and what can be and is being done to check soil and water losses.

Soils That Reward

STANDING ON A HIGH POINT in the Appalachian region in 1828 with his back to the East—an East already partially impoverished by cropping and erosion—Andrew Jackson is said to have told a friend: "From here out to the Mississippi River there is enough good land—to take care of all the population we will have in the United States for the next 700 years." This valley, over which Jackson pointed, a "most spacious habitation for human life" is a thousand miles wide, one-third the width of the continent. Save for occasional gentle hills, the valley spreads in comparatively level reaches from the western slope of the Alleghenies to the eastern base of the Rockies. Centered in this spacious sweep is a midland empire, the American Corn Belt. This area, drained principally by the Mississippi, the Missouri, and the Ohio, three mighty rivers, embraces 250,000 square miles of land (fig. 3).

To locate the Corn Belt (fig. 15) a bit more precisely, yet within limits imposed by a conventional map of the United States, it may be enclosed roughly as follows: Start a pencil line at a point slightly south of Sandusky, Ohio, on the southern shore of Lake Erie. Go west to Chicago, then strike boldly in a northwest direction to a point about midway on the Minnesota and South Dakota State border. Swing southwest to a point about midway on the Nebraska and South Dakota State line. Include all of eastern Nebraska and a portion of northeastern Kansas. From the Kansas-Missouri State line take a northeasterly direction through Missouri, Illinois, Indiana, to, say, Chillicothe, in south-central Ohio. Turn north and return to the starting point on the bank of Lake Erie.

With lavish generosity, nature provided the Corn Belt with a fertile soil and for the most part a favorable climate (fig. 4). It is among the greatest of all contiguous areas of good land.

The underlying soil material in a large area of the eastern Corn Belt is of limestone origin. However, portions of Ohio, Indiana, Illinois, and northern Iowa have been glaciated. In the western portion of the Corn Belt the extensive soils derived from wind-blown or loess material came in large part from the less humid regions to the west.

FIGURE 3.—The Corn Belt is drained principally by the Mississippi River and its tributaries.

FIGURE 4.—A fertile soil and, for the most part, a favorable climate are the chief characteristics of the Corn Belt.

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Heavy rainfall and high temperatures during the summer are normal features of most areas in the Corn Belt. Rainfall in central Ohio is normally about 37 inches a year, and westward the precipitation becomes less and less as one edges out of the cornland and approaches the eastern border of the Great Plains. Here the precipitation drops to about 20 inches.

Speaking generally, prairie grass was the original vegetation in the western Corn Belt, whereas all of the eastern section was wooded. This billowy sea of grass, broken only occasionally by tree-fringed streams, was strange to the new settlers when they arrived from the wooded East. To the grasslands they brought their forest traditions and experiences. M. L. Wilson, Under Secretary of Agriculture, has written:

> They came from a humid forested Europe and settled in a humid forested America * * * When the pioneers first moved westward they sought wooded lands for farming. Records show that the early settlers sought the wooded flood plains first for their homesteads. Here the trees were cleared with the greatest effort to provide farming land. Only by accident was it discovered that the interstream area was equally if not more productive * * *.

In this strange environment settlers found grass 6 and 8 feet tall. Men and horses could be lost in it. Timber had not gained a foothold. The sod was so tough, the earliest settlers claimed, that many a plow was broken. But they also added that the first crop of corn would run about 50 bushels to the acre; wheat 25 to 30; oats, 40 to 60; and many other crops they tried for the first time yielded in abundance.

Although the Corn Belt includes only 8 percent of the land area in the United States, in this region will be found more than one-fourth of the cattle, about one-third of the horses, and more than half of the hogs of the Nation. The United States produces from half to two-thirds of the corn crop of the world, and nearly two-thirds of the United States crop comes from the Corn Belt. For years the Corn Belt has been a great surplus meat-producing region, but it is now a surplus milk-producing region as well.

Productiveness in the Corn Belt has been proved; yet we now know that a revolution began when the sod was first turned and trees were cleared from the land. For thousands of years Nature labored in building soil against the day when the white man appeared with his ax, plow, and match. Meanwhile this property was under the stewardship of Indians, whose culture and traditions were admirably suited to leaving Nature alone. The white man, with easily understood compulsions, has invented and used ingenious devices to unlock and appropriate the stored treasure of the ages. In most instances he not only has prevented Nature from maintaining the storehouse of soil fertility but has opened the way for natural forces to become destructive.

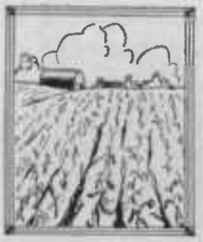
By and large, under natural conditions, topsoil—the original surface soil—is removed no faster than it is replaced through the slow, very slow, building processes from beneath. For example, it probably took Nature at least 500 years to make each inch of the Shelby loam soil which covers vast areas in south-

ern Iowa and northern Missouri. This rate, though slow, was fast enough under undisturbed natural conditions to keep the soil stabilized.

Against Nature's leisurely but colossal job of soil building, consider the 20 inches of topsoil which an Iowa farmer measured in the lowlands of his pasture, carried there from his upland cornfield by the water of one June rain (fig. 5).

FIGURE 5.—This Iowa farmer found 20 inches of silt deposited in the lowlands of his pasture after a heavy rain in the spring of 1936. Most of the silt came from his cornfield that lies up the slope.

Soils That Fail



LAND UNDER CULTIVATION on most farms declines in natural productivity because plant nutrients leave the farm on one-way tickets. Seldom are soils managed in such a way that an equivalent amount of plant nutrients is returned to offset the losses. Too much is going off the farm, and too little is being returned. This loss is not so apparent on the naturally fertile soils. Yet even on these, if cultivation is continued, the day is sure to come when yields will decline if fertility is not conserved.

Such reasoning may sound primerlike to farmers who for years have been required to replenish fertility elements through legumes, commercial fertilizer, and animal manures. Yet there are farmers, particularly those whose experience has been confined largely to a virgin soil, who believe that it is poor judgment to farm land that needs replenishing.

Four important processes lead to the declining productivity of a soil. These are: Leaching, crop removal, depletion of humus, and erosion. On any given soil one or more of these processes may be at work in pulling down the yielding power. Although erosion began when the first raindrops fell upon a bare sloping soil, the most harmful soil and water losses generally appear after soils have been subjected to the cultivation of clean-tilled crops or to excessive grazing. Since leaching, crop removal, and changes in the soil structure are often the forerunners of severe erosion, these processes are briefly discussed.

Leaching

As water percolates downward through the soil either to artificial drainageways such as tile or to the water table, certain water-soluble plant-food elements are carried with it. These elements are lost because they are beyond the reach of plant roots. The extent of loss depends upon the amount and distribution of rainfall, topography, permeability of the soil, and the cropping system employed. In regions of plentiful rainfall like the Corn Belt, losses of calcium, magnesium, and nitrogen may be severe. Certain agricultural practices intensify the leaching process but on many soils that are poor today, these losses have been going on through the extended geological period of soil development. Soil profiles

as seen from a limestone quarry near Middle Point in northwestern Ohio, show the limerock to be but 3 or 4 feet under the surface of the soil. Yet soil tests on many farms of the immediate vicinity reveal the necessity of a lime application for an optimum growth of legumes. This situation exists in many areas in the Corn Belt.

Crop Removal

Chemists can determine the quantities of plant nutrients that have been carried away from the land to the grain elevator, the stockyards, and the milk plant. For example, 40 bushels of corn, hauled to the elevator, removes about 56 pounds of nitrogen, 21 pounds of phosphoric acid, and 23 pounds of potash, three of the most essential elements, of which usually there is not enough in the soil for plant growth (fig. 6). Forty-five bushels of oats will remove about 55 pounds of nitrogen, 20 pounds of phosphoric acid, and 46 pounds of potash.

In livestock farming where crops are marketed principally through animals, the plant-nutrient loss is considerably less if the manure accumulations are properly handled. Yet even in livestock farming there is a constant drain on the phosphorus supply from the soil. Five 200-pound hogs, or a 1,000-pound steer, will remove as much phosphorus in their carcasses as can be returned in a 100-pound bag of 16-percent superphosphate.

FIGURE 6.—Crops remove plant nutrients from the soil.

The potash supply in most Corn Belt soils is rather large. Difficulty in making it available fast enough for the best plant growth, however, has focused attention on the amount being removed through cropping. Experimental crop plots at Purdue University, started in 1916, show that on certain types of land yields increase slightly if one-third of the potash removed in crops is returned to the soil through commercial fertilizers.

Depletion of Humus

Even though losses from leaching and crop removal may be measured with reasonable accuracy by laboratory methods there are other losses which, though known to be serious, are not so easy to count from a dollar-and-cents or a pound point of view. Before taking up the discussion of losses from erosion it is necessary to consider humus, the decomposed organic matter. Soils heavily charged with humus are the soils gardeners and others delight in using for house-plant pots. Such soil is usually dark in color and the dark color of the original Corn Belt soils indicates humus in generous amounts.

Soils heavily charged with humus, or organic matter, are not so erodible, as a rule, as those deficient in organic matter. Humus enables soil particles to cling to each other. When decomposed, humus enhances the mechanical condition of a soil, making it possible for air and water to penetrate more easily. Naturally heavy soils are made more friable and porous because humus has promoted a crumblike structure. This structure in turn enables the soil to absorb, distribute, and provide water for plants in large volume. The greater plant growth results in more effective cover. In sandy soils humus increases the water-holding capacity, thus effectively minimizing leaching and erosion. Soils high in organic matter, tests have shown, frequently contain 15 to 30 percent more granules than soils low in organic matter. The tests also show that soils containing a high percentage of these granules are several times more resistant to erosion than are soils low in the percentage of granules.

Many years ago, probably between 5,000 to 10,000, a shallow sheet of water extended over a large area in northwestern Ohio and into a comparatively small area in northeastern Indiana. In time these waters receded to the banks of Lake Erie, leaving as nearly level a strip of land as may be found anywhere. On this old lake bed grew a dense forest—a forest so dense and forbidding that land seekers swerved both north and south of it in their westward migration. Old-timers in central Ohio love to tell about their deer-hunting expeditions in the Old Black swamp.

About 1880 men discovered that this area offered possibilities for cropping purposes if drained. Hastily constructed waterways carried off the surplus water to the larger natural drainage channels. Yet the land was so level that water from the heavier rains occasionally stood too long during the growing season, thus ruining crops. The water had to be taken from the land more

quickly. Tile drainage had proved its worth in the East, and this method of reclamation was quickly adopted in the Black swamp—Ohio's last frontier. Commercially manufactured tile were not always available at first, and settlers resorted to the split-log type of drain. These split-log drains, and the manufactured type, when available, were usually placed about 6 rods apart in parallel lines extending the full length of the field. Men now living affirm that seldom was there any crop loss from water standing on their fields the first few years after these drains were installed.

This Old Black swamp in time became a typical cash-grain section identified easily by the towering grain elevators thickly spaced along the several railroads.

By 1920 farmers began to notice that, after years of almost continuous cropping to corn and oats, their fields were not draining as well as they once did. Tile draining had solved the problem once. Perhaps more drainage was necessary? Power ditching machines were available in the twenties, and many of these machines could be seen at work in fields digging ditches for new tile drains. Usually the new ditches were run midway between the original drainage lines that were 6 rods apart. The new and old system combined gave underground water outlets every 3 rods across the field. Doubling the drainage lines helped somewhat, but many farmers were puzzled when they reflected that they were not getting as much drainage from tile 3 rods apart as they once obtained from tile 6 rods apart on the virgin land. Moreover, today farmers claim that their land is heavier, that it is more difficult to work down into a good seedbed, that it cracks worse in dry weather, and that it is more difficult to obtain a satisfactory clover stand.

When trees are cleared from the land the root remnants serve, during the process of decay, as natural drainage channels. When decay is complete these avenues for the downward passage of water become closed. Furthermore, with the depletion of humus in the surface soil under a continuous cropping system the water-holding capacity has been reduced, and the granular structure has been impaired, making the soil more compact and impervious. This accounts in large part for the decreased efficiency of tile drainage in the Black swamp.

Soil is made up partly of solid material and partly of pore space filled with air and water. The volume weight of soils high in organic matter is less than the volume weight of similar-textured soils low in organic matter. This difference is due in part to the lighter weight of organic material and in part to the greater pore space in the soils high in organic matter. Soils high in organic matter are as a rule more spongy and more easily penetrated by plant roots. In 1935 Richard Bradfield, soil physicist for the State of Ohio, investigated the effect of 40 years of cropping on the Nappanee silty clay loam in Paulding County. He compared virgin soil that had been in grassland with the cropped land immediately over the fence. The results of this study are shown in table 1.

TABLE 1.—*Effect of 40 years' cropping on Nappanee silty clay loam, Paulding County, Ohio*

Depth of soil (feet)	Weight of soil per cubic foot		Pore space as percentage of total volume		Organic-matter content per acre	
	Virgin	Cultivated	Virgin	Cultivated	Virgin	Cultivated
	Pounds	*Pounds*	*Percent*	*Percent*	*Pounds*	*Pounds*
0–1	65. 5	81. 7	60. 3	50. 5	132, 000	89, 400
1–2	70. 3	86. 7	58. 1	47. 6		
2–3	76. 6	91. 0	53. 5	44. 8		
Average	70. 8	86. 5	57. 3	47. 6		

FIGURE 7.—The result of one heavy rain in Ohio. Erosion removes many times as much plant nutrients as is lost through cropping and leaching combined.

Gone With the Rain

TODAY, THE PRODUCTIVE TOPSOIL—the living surface—on most of the Corn Belt land is being damaged more severely by erosion than by all the other deteriorating processes combined. It is now known beyond question that, along with the body of the soil itself, erosion carries away many times as much plant food as is lost through leaching and crop removal combined (fig. 7). While this statement implies a change in chemical composition of the soil following erosion, the physical effect is frequently serious.

The principal factors influencing soil erosion are: (1) Amount, distribution, and intensity of rainfall; (2) the topography of the land, which includes the degree of slope, the length of slope, and the total slope area drained by the individual drainageways; (3) the erodibility of the particular soil type; (4) the type of soil-management practiced; and (5) the vegetative cover.

Rainfall

Every Englishman, it is said facetiously, passes through life clinging to the handle of an umbrella. Nevertheless when annual accounts are cast up, it is found that the total rainfall in London is but two-thirds that of Illinois. London gets about 26 inches of rain during the year, while Illinois receives about 38 or 39 inches. London and the Sacramento Valley of California receive approximately the same annual rainfall. London has frequent gentle rains coming on 200 days of the year, whereas in the valley most of the rains come during 3 months, in about 65 days. At Culebra, Isthmus of Panama, our Government found that it could not raise vegetables without irrigation even with a rainfall that totals 84.64 inches a year.

It is not the amount of rain that falls during the year that is important; how it comes and when it comes, rather than merely how much comes, largely determine soil and water loss. In other words, it is the intensity and distribution that are important. There would be less erosion in the Corn Belt if the rainfall were as well distributed throughout the season as it is in England. In the Corn Belt a considerable part of the season's rainfall comes during the spring and early summer months, when the land is being prepared for corn, and later when the corn is being cultivated.

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One rain in some seasons has done more damage than all the others combined. Similarly, a single rain in 1 year may cause nearly as much loss as the total rainfall of a preceding year. On April 3, 1934, 3.33 inches of rain fell at Bethany, Mo., a downpour at the rate of 2.78 inches an hour. A plot of cornland lost 45.58 tons of soil an acre. The year before, this same plot lost 49.76 tons an acre. Furthermore the water lost as run-off from this one April rain in 1934 was 26.43 percent of the total for the preceding year. Water coming down in such volumes as fell with this rain is extremely damaging unless the soil has an adequate cover of vegetation to reduce the soil-carrying velocity of the water.

When the soil is frozen, its absorptive capacity for holding rain water is very low. Furthermore, warm rains may thaw the soil for a few inches. If a heavy rain falls on land in this condition much of the water runs off the land, carrying the unfrozen surface soil with it.

Slopes

Water runs faster down a steep slope than on one less steep, other factors being equal, and fast-moving water is very erosive. Theoretically if the velocity of water is doubled, the scouring capacity is increased 4 times, the carrying capacity 32 times, and the size of the soil particles carried 64 times. Length of slope is important because it determines the volume and velocity of run-off. Long slopes permit water to gain velocity, and velocity plus the increased volume accelerate the eroding power.

In experiments conducted at Columbia and at Bethany, Mo., 61 tons of soil per acre was washed away annually when corn was grown continuously on land having an 8-percent slope. On similar soil with a slope of 3.7 percent the annual loss was 20 tons of soil. At the Soil and Water Conservation Experiment Station at La Crosse, Wis., in 1935 a plot of sloping land 36.3 feet long, planted to corn annually, lost 62.52 tons per acre; a plot 72.6 feet long, 88.35 tons per acre; and a plot 145.2 feet long, 100.24 tons.

In general, experimental results indicate that when there is no covering of vegetation the slope of the land is an important factor governing erosion, whereas the slope may be less important if the land has a good vegetative cover. Each year a large percentage of the land in the Corn Belt is bare in the spring and early summer and in the late fall, after crops have been harvested (fig. 8).

Soil as Related to Erosion

Some soils wash easily, while others under the same amount of rainfall and with comparable slope and vegetation erode very little. Coarse-textured soils generally resist erosion because they permit rain water to penetrate readily, thus reducing the amount of run-off. However, some sandy soils have a heavy impervious subsoil and therefore permit rather severe erosion. The individual

soil particles in a coarse-textured soil (sand and sandy loam) are larger and heavier than those in a fine-textured soil. This additional weight makes it more difficult for water to dislodge the particles. Soils having a characteristic granular or crumblike structure are more resistant to erosion. This desirable structure is found when the individual soil particles are combined and the resultant group acts as a unit physically.

Some soils puddle easily on the surface. When this is the case water will not penetrate readily and it must stand on or run off the surface.

Still other soils have a more or less impervious subsoil. On these soils erosion is more severe because water must run off or stand in puddles when the topsoil has absorbed all that it will take.

Structure, texture, and organic matter are intimately related factors and it is their combined effect that determines the erodibility of a particular soil on a given slope. Soils vary widely as to their capacity to absorb water. For example, tests show that the Marshall silt loam is about seven times as absorptive as the Shelby silt loam.

Of all the factors influencing erosion, the management of the soil and the cover provided are the only ones that can be controlled by the farmer. Little or nothing can be done to change climatic conditions; nothing can be done to change the general topography of the land; but much can be done by the employment of old and new measures of soil defense. These measures of defense are discussed in the section headed "From Corn to Cover."

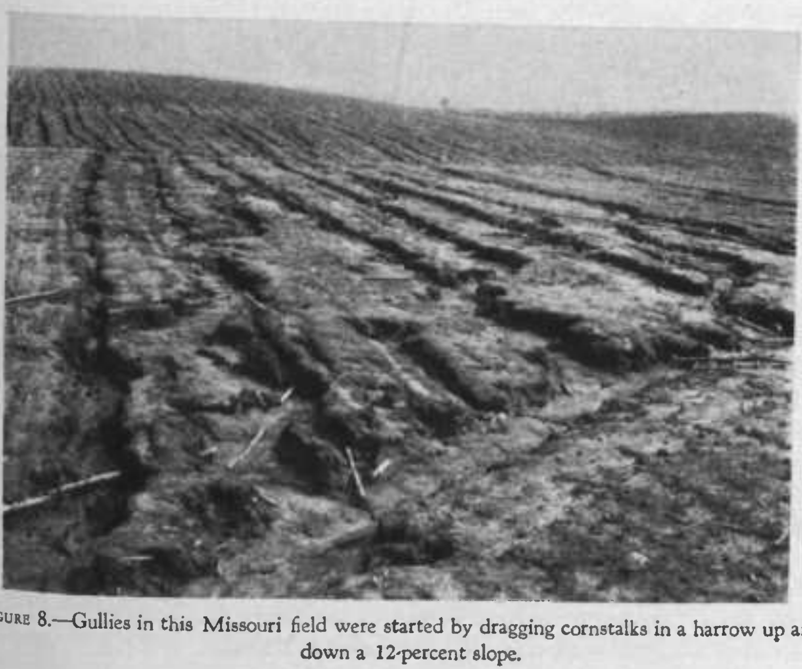

FIGURE 8.—Gullies in this Missouri field were started by dragging cornstalks in a harrow up and down a 12-percent slope.

Erosion Losses

Dust storms, or newly etched gullies if large enough, may be counted upon to get attention. The far more serious aspect of erosion, the loss from a field of fertile soil in thin layers, usually goes unnoticed. This need not be surprising since most farmers for years have been watching the knolls in their fields become lighter in ever-widening circles like the bald spot on a man's head, but it was not called sheet erosion as we now know it to be. These lighter spots often received the only manure available on the farm, but even so they continued their march toward the lower levels. When the topsoil becomes too thin, deeper and deeper levels of subsoil are raised to the surface each time the field is plowed. This subsoil becomes mixed with topsoil that still contains some partially decayed organic matter. As a result the color of the soil gradually becomes lighter.

Soil conservationists describe water erosion as sheet erosion and as gully erosion. In reality, there is no sharp dividing line between the two terms. On unprotected uplands sheet erosion planes down the surface of the soil in thin imperceptible sheets. These sheets of soil may move off so gradually to the lower levels that no gullies are carved but damaging sheet erosion is at work just the same. If rains are intense and rows of cultivated crops go up and down or if there is a natural low point where water can concentrate in flowing down the slope, gullies will appear. Gully erosion seldom appears until after half or more of the topsoil—the original surface soil—has been removed by sheet erosion.

Estimating the Losses

One of the first tasks which the Soil Conservation Service attempted after its organization in 1933 was to make a general survey of erosion conditions throughout the country. These surveys were made in cooperation with experiment station officials and others within each State.

Iowa is the only State that lies wholly within the Corn Belt area. Its survey figures, therefore, probably are more nearly representative of the erosion conditions of the Corn Belt than are those of any other State. The total land area of Iowa, exclusive of large cities and water areas, is 35,575,000 acres. Of this acreage, about 45 percent has not been seriously affected by erosion. The remainder has been affected in some degree by either sheet or gully erosion or both.

Wind erosion throughout the Corn Belt is very limited. Iowa is credited with having but 3,160 acres affected by wind erosion. However, several of the Corn Belt States extend into areas where wind erosion is a serious problem. These States are South Dakota, Nebraska, and Kansas. Northern Indiana is affected to a limited extent, as are a few areas in Illinois.

The above State-wide estimates reflect the seriousness of the problem from the national standpoint. To the farmer, the loss of topsoil—the original surface cover—from his own farm is the pertinent problem. Any farmer can, roughly, determine how much topsoil has been lost from his own acreage. By simply taking a spade and examining those areas which have never been disturbed by cultivation or overgrazing, he can determine the original depth of the topsoil. If he then steps over to a cultivated area and examines the depth of the topsoil, the difference in depth will show the loss that has been sustained. A good place to look for the virgin spots is in old churchyards, schoolyards, along railroad rights-of-way, in virgin forests that have not been pastured, and on other undisturbed areas.

One farmer in Iowa measured the depth of soil in a churchyard and found 18 inches of topsoil. In a cultivated field 400 feet away, on a 5-percent slope, he found only 3 inches of topsoil. Another Iowa farmer believes that he has convincing evidence that 3½ feet of soil has been lost from a slope in one of his fields. A former owner of the farm installed a pipe 4 feet underground, to bring water to the buildings. A son of the present owner plowed this field in the spring of 1936. Coming in from the field one day, he announced that the subsoiler on the plow had been broken by striking the pipe, which was only 6 inches below the surface of the ground.

Measuring the Losses

Only recently has erosion emerged from the realm of discussion to the realm of measurement. In 1917 M. F. Miller and F. L. Duley, of the Missouri Agricultural Experiment Station staff, designed and installed the first plots for the controlled measurement of soil and water losses under various crops and conditions. Their method, still standard, is to catch water and silt at the lower end of each plot and compare the results. Computations made in connection with these tests and at the more recently established soil and water conservation experiment stations throughout the country provide the basis for the first extensive measurements on losses from erosion. Each of the stations, 15 in number, is situated on soil representative of a large area. The Corn Belt has two such stations (fig. 9).

Estimates on the longevity of the topsoil of the Iowa cornland (7 inches)—24,600 years under bluegrass, 169 years under rotation, 48 years corn, continuously—are based on recent results obtained on Marshall silt loam with a 9-percent slope at the Soil and Water Conservation Experiment Station at Clarinda, Iowa.

Forty-three years ago the Ohio Agricultural Experiment Station laid off plots of land to start a long-time study of the effect of continuous cropping on the fertility of the soil. Early records indicate that no one assumed there would be

any soil loss from this land which slopes from 2 to 4 percent (2 to 4 feet to each 100). Recently 36 borings were made in scattered spots on each one-tenth acre plot. These measurements were compared with those on uneroded soil.

The soil loss from plots kept in corn continuously for 41 years is estimated at 8.9 inches over the section as a whole. Over most of the section the upper subsoil has been turned up in plowing, "indicating that at least two-thirds of the surface soil has been washed away." Tile originally placed 28 to 30 inches underground now lie at a depth of 18 to 24 inches below the surface. Measured in tons, the annual soil loss from the corn plots has been 35 tons per acre.

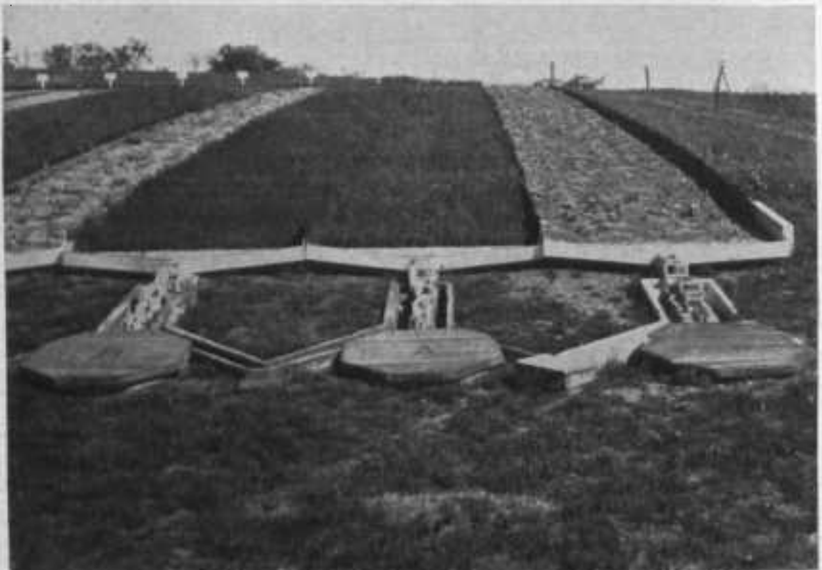

FIGURE 9.—Experimental plots such as those shown above provide the basis for measurements of soil and water losses.

Loss from plots kept in oats continuously have been striking. It is estimated that 5.2 inches of soil have been washed away, an average of about 19 tons per acre per year.

On more sloping land (that sloping from 1 to 8 percent) plots growing corn, oats, wheat, and clover and timothy in rotation show severe losses of soil. The loss on the unlimed half of the section varies from 4.5 inches where the slope is about 1 percent, to 13.4 inches on a low ridge where the plow soil is made up largely of lower subsoil material. Rotation somewhat reduced the soil losses as compared with those on plots continuously cropped to corn and oats, but the steeper slopes made even rotation inadequate as a single measure of defense.

From Corn to Cover

FOOD, CLOTHING, and a log cabin were all of the demands placed upon the Corn Belt soil in the early days of settlement. When the cornland reached its most productive period after settlement, a typical Corn Belt farm often supported two families, one on the farm, the other in the village. This intensive demand on the land is as severe and exacting as ever, but the natural productive capacity of much of the land is seriously impaired.

The productive capacity of much of the land has declined through misuse. This misuse of land in the past has frequently been aggravated by a faulty system of credit, a faulty system of land tenure, unstable prices, and other factors, separate and combined. During the World War years the plow was pushed onto steep slopes, baring additional and more vulnerable acres to the battering forces of erosion. After the war, fixed charges against the land made it seem necessary to keep most of these acres under cultivation, thus lengthening the period of damage.

But recriminations are useless. The practical problem today is to hold onto this remaining soil while deriving a living from it.

In this section several methods of soil and water conservation are discussed. Some of these methods have been tested through many years of experience in older regions of the country. Others have had less testing in point of years but have been subjected to intensive observation and application in a relatively short period of time. Strong and weak points of the several methods under varying conditions have been brought to light. These numerous methods of conserving soil and water, herein set forth, are not offered as one, two, three steps for a farmer to apply. Rather, these suggested measures of defense are sketched and listed so that each farmer may select intelligently the combination of practices best suited to his requirements.

On project areas of the Soil Conservation Service, these practices are discussed thoroughly with each farmer on his own land. When a joint agreement has been reached between the farmer and agents of the Service, an erosion-control program best fitted for the particular farm is ready for use.

Land Use

Nature, if left undisturbed, clothes the soil with a protective mantle of vegetation—grass, shrubs, vines, and trees, or varying combinations of these. Since the Nation needs food, it is obviously impossible to return all land to its original state of forest and grass. However, too much land has been and is now exposed to erosion. The obvious first step for the Nation and the farmer is to convert, as soon as possible, the more erodible land, usually the steeper slopes, to pasture and timber. At the same time, it is obvious that the cultivated acres should be handled in a way that will reduce erosion losses to a minimum. In general, this means an increase in the legume and grass acreage and a decrease in the acreage of row crops like corn.

In placing some of the land under a more adequate cover of vegetation one is at once confronted with the problem of income. Indeed, the job of maintaining or increasing the net farm income, over a period of years, is the highest hurdle confronting the farmer.

At the outset it must be admitted that on much of the severely eroded land a change in method involves no sacrifice in income because these eroded acres are producing such meager crops that the income is very low.

On much of the land that is still productive it is possible to grow more on fewer cultivated acres and release the more erodible portion of the farm to grass and trees. The immense volume of information assembled by experiment stations on cropping practices suggests how the income may be maintained by cultivating fewer acres. In 1876 soil-fertility plots, the oldest in the United States, were established on what is now the campus at the University of Illinois. More than 60 years ago, the late George E. Morrow, in whose honor the plots are called the Morrow plots, conceived the idea of a long-time experiment to study the effect of different cropping practices. His plan was to grow corn continuously on one plot; a rotation of corn and oats on a second; and corn, oats, and clover on a third. Thirty-four years ago each of the plots was divided into two equal parts. The original plan was continued on one half of each plot, and on the other half a system of soil building was started which has been continued to the present time.

Assuming that we have 120 acres of cropland, similar to that in the Morrow experiment, let us see how much land could be spared from corn production, basing our calculations on results obtained from these Morrow plots. When corn is grown continuously on the same land, the yield has been 23 bushels per acre. On 120 acres this would total 2,760 bushels. If a rotation of corn, oats, and clover is used, it would require but 54 acres of cornland to produce the 2,760 bushels. If limestone, phosphorus, and manure are applied in the rotation, it requires approximately 42 acres to give the 2,760 bushels of corn, leaving 78 acres for small grains and hay, thus proving that it is not an impossible

handicap to reduce the acreage of corn in favor of crops more resistant to erosion if those acres in corn are handled in a more skillful manner.

Furthermore, it should be remembered that if some of the more erodible land is devoted to trees or pasture these retired acres may also do their share in bringing in farm returns. Foresters in Ohio report that on the basis of the yield of one standard cord of wood, or 300 board feet of saw timber, annually per acre, the net income to the owner above labor and taxes ranges from $2 to $6 a year, and this net income continues annually as long as these woodlands are properly managed and protected from fire and grazing. They estimate that on the average Ohio farm at least 10 acres can well be used for the production of fence posts and timber for farm use, for sale, and for fuel (fig. 10).

FIGURE 10.—Steep forested hillsides are probably devoted to the crop to which they are best adapted.

Pastures, though usually the most neglected acres on Corn Belt farms, probably contribute more to the net farm income than is generally appreciated (fig. 11). It costs from three to four times as much to feed a cow in the stable as on pasture. The Indiana Agricultural Experiment Station found, in surveying 24 pastures in Washington County in 1927, that it would require a yield of 20.5 bushels of corn per acre to equal the feeding value in an acre of permanent bluegrass. Approximately 3.4 acres of these pastures fed one cow for 180 days. This same station in a 3-year feeding test found that lambs of pasture-fed suckling mothers returned $4.61 more per lamb than did the lambs of the grain-fed mothers.

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FIGURE 11.—Good pasture is both a crop and a soil conserver. Todd of Ohio found that treated pastures compared favorably in value with land in rotation which produced 52 bushels of corn, 24 bushels of wheat, and 2.2 tons of hay per acre. The rotation produced slightly more dry matter but the pastures were decidedly ahead on the production of protein. Erosion control alone frequently justifies the cost of pasture improvement.

FIGURE 12.—Inadequate food and cover, caused principally by the removal of natural vegetation, has resulted in the almost complete extinction of some wildlife species.

Soil conservation and wildlife conservation go together naturally. Vegetation is nature's own weapon against soil erosion. Vegetation, likewise, provides food and cover for wild creatures. Lack of adequate food and cover, caused principally by the removal of natural vegetation, has resulted in the almost complete extinction of some species of wildlife. If the rougher and more erodible land is retired to pasture and trees, and shrubs, trees, and grasses are planted in gully-scarred areas, valuable species of wildlife can be saved and increased (fig. 12).

Saving Soil on Tillable Land

Better Cropping Systems

Different crops vary widely in their influence upon erosion losses. Intertilled crops, such as corn, potatoes, soybeans, and tobacco, may be classed as erosion inducing. Sod crops, as well as most legumes, may be classed as erosion resisting. Other crops, such as the small grains, stand between these extremes and may be classed as an intermediate group.

The soil loss under a given crop will vary with the length and degree of slope, permeability of the soil to water, rainfall, and other factors. However, on a given piece of ground it is a simple matter to chart the comparative influences of different crops on soil and water losses. The Missouri Agricultural Experiment Station, at Columbia, in a 14-year test, found a wide difference in the erosion-resisting effects of different crops grown on a Shelby silt loam. On a 3.68-percent slope, 90 feet long, the average annual soil losses in tons were as follows: Bare cultivated land, 41 tons; continuous corn, 19.7 tons; continuous wheat, 10.1 tons; corn, wheat, and clover in rotation, 2.7 tons; continuous bluegrass, 0.3 ton. Water losses, expressed as that percentage of the total rainfall that runs off the land, were as follows: From bare land, 30 percent; continuous corn, 29 percent; continuous wheat, 23 percent; corn, wheat, and clover in rotation, 14 percent; and continuous bluegrass, 12 percent.

These results show that whereas corn kept cultivated throughout the season permits heavy soil losses (20 tons) the loss is doubled if the land is kept bare and fallow. Wheat grown continuously, in this test, reduced the soil loss to 10 tons, whereas on permanent grass the loss was almost negligible. It might be assumed that the soil losses from continuous corn, continuous wheat, and continuous bluegrass might be averaged and the result would be 10 tons on a rotation of corn, wheat, and clover. The actual loss per acre under the rotation, however, was only 2.7 tons.

The difference in soil losses between crops grown in rotation and crops grown continuously on the same land is apparent. Under continuous cultivation of corn the land is essentially bare the year round, while under the rotation system the clover sod preceding corn is usually not plowed until April. Since wheat

follows the corn in October the land is exposed to the dash of rain from April to October only. Under the rotation system, clover is sown in the wheat in the spring, and the combined effect of the two crops is to resist erosion. In addition clover adds organic matter to the soil, and this in turn makes the soil more absorptive of water, thus reducing erosion. On sloping land all seedings of hay crops should be made with a mixture of legumes and grass. Legumes alone are not the best erosion-control crop.

Since soybeans are a legume and legumes are generally recognized as soil improvers, many farmers have overlooked the fact that this crop may permit serious erosion. Where soybeans are grown in rows at corn-planter widths and cultivated, they allow practically the same soil loss as corn. On rolling land, the nitrogen carried away in the eroded soil may be greater than that added by the plants. If the soybeans must be sown in rows and cultivated, the rows should run on the contour.

Many factors determine the adaptability of a cropping system to a given soil. So far as erosion is concerned these factors are chiefly confined to a consideration of the slope, native fertility, depth of the surface soil, character of subsoil texture, and lime requirement. Corn is a very prominent crop in the cropping system of those Corn Belt soils that are deep, fertile, and comparatively level. Small grains are better adapted to soils of less fertility and on steeper slopes. A portion of the corn acreage on these soils should be replaced with grain or sod crops. On the soils still less fertile, and if the slope is rolling to steep, corn may have to be eliminated entirely in favor of small grains and sod crops.

Probably the most important single step that Corn Belt farmers can employ in erosion control is to establish and maintain a satisfactory rotation of crops. By properly rotating the crops and by alternating the intertilled crops such as corn and soybeans with nontilled crops such as alfalfa, clover, timothy, other grasses, and small grains, the land is exposed to serious erosion only about a third to a fourth of the time. Farmers in the eastern part of the Corn Belt, generally speaking, have adopted rotation systems to a greater extent than have the farmers farther west. Fifty percent or more of the cropland in western Iowa is used for intertilled crops, principally corn and frequently on slopes exceeding 10 percent. Small grains and leguminous-hay crops should be substituted for a portion of the intertilled crops over wide areas in the Corn Belt.

A rotation system, however, in itself is inadequate. Results are forthcoming only when the system actually works. Clover failures from any cause will mean that the maximum effect in erosion control will not be obtained. It is difficult and often impossible to obtain deep-rooted legume crops on acid soils unless limestone is applied to correct the acidity (fig. 13). Adequate crop rotations in the Corn Belt cannot be established without first correcting the acidity. Furthermore, many of the soils in the Corn Belt have reached the point where it is necessary to supply commercial fertilizers to obtain profitable crop yields and satisfactory legume stands.

Contour Farming

Contour farming is new to most farmers in the Corn Belt. In contour farming one tills the field across the slope, or around the hill and not in straight or parallel lines suggested by roads and fences. Each small ridge and furrow thrown up by implements in going around the slope on the level helps to hold water where it falls, thus reducing the run-off. On the other hand, as in straight-row property-line farming, small furrows up and down the slope are troughs which carry silt-laden water rapidly downhill (fig. 14).

Contour farming is widely practiced in some sections of the South. In his bulletin, Soil Defense in the Piedmont (U. S. Department of Agriculture Farmers Bulletin No. 1767), E. M. Rowalt says that one may drive for miles in some parts of the Carolinas, Georgia, and Alabama, where most of the soils are of a moderate to highly erodible character, without seeing a straight row of cotton or corn. Of necessity, farmers there resorted to contour cultivation in an attempt to save their soils, and all rows approach the horizontal without regard to the undulations of slope in the field.

At the Soil and Water Conservation Experiment Station at Clarinda, Iowa, contour farming has proved one of the most effective measures of soil defense. On a 9-percent slope, with corn planted on the contour there was no appreciable loss of water or soil in 2 years' time. The small ridges on the contour held every rain, even the one which amounted to 3 inches in 4 hours. However, under

FIGURE 13.—Much of the land in the Corn Belt now requires an application of lime to insure adequate legume growth for profit and erosion control.

field conditions it is not always possible to have all tillage operations follow the contour accurately, and water may accumulate in the lower spots. When this is the case, it is necessary to provide grassed waterways in the low places to carry water safely away. Even on soils as absorptive as the Marshall silt loam, the type of soil found at Clarinda, other measures of defense in many cases must be combined with contour farming for adequate control.

Since farming operations in the Corn Belt have traditionally been conducted in parallel lines or at right angles to roads and fences, some difficulties are encountered in changing to contour farming. Many necessary adjustments must be made. Most men, however, who have tried contour farming claim the advantages far outweigh the disadvantages. In addition to saving soil these men frequently say: (1) Contour farming saves power since machinery is drawn on the level; (2) there is not so much turning because there is a greater percentage of longer rows; and (3) the increased moisture held on the land increases the yield of crops.

Engineers at the New York (Cornell) Agricultural Experiment Station at Ithaca have found that 33 percent of the time required to plow a field 10 rods long is consumed in turning. In a field 120 rods long only 4 percent of the time is required in turning.

FIGURE 14.—Small furrows, left by the cultivator in following corn rows up and down the slope, started these gullies. True, they will be obliterated when the land is again prepared for a crop, but much soil and water will have been lost.

Strip Cropping

Strip cropping is one of the newer measures of soil defense now being practiced widely throughout the country. Terracing and contour cultivation have been used for years in certain sections to check soil and water losses. Strip cropping is now being employed sometimes alone and sometimes as a companion measure to terracing. All measures of soil defense, either separate or combined, have as their primary purpose slowing down the rate of water flow. Only swiftly moving water carries large quantities of soil.

To strip-crop (figs. 16 and 17), one plants bands or strips of close-growing crops on the contour, alternating these strips with strips of cultivated crops. The close-growing crops include most of the legumes, grasses, and small grains. Strips of close-growing crops filter out the soil particles from silt-laden water running down from above. The flow of water is checked because it meets innumerable obstructions. Slow-moving water drops its load, and the water is given more time to soak into the ground. If row crops are protected from the wash above by a strip of a close-growing crop and if there is another strip below ready to slow down the moving water, little soil is likely to move from the field.

In general, the width of strips ranges from 75 to 200 feet. On more erodible soils and on steeper slopes the strips of cultivated crops should be narrower than elsewhere. Or, to state it in another way, if the soil erodes severely, the strips of thick-growing crops should be placed closer together. The rotation of corn, oats, and clover would provide one strip of corn, a strip of oats, and a strip of clover, or any multiple of this combination. Soil washed from the strip of corn would be lodged in the strip of hay.

Assuming that a farmer has a clover field which he wishes to strip-crop to corn, oats, and clover, the illustration in figure 18 will show how this may be accomplished without a serious derangement of the rotation sequence. If a corn, wheat, and clover rotation is preferred to the one illustrated, the adaptation can easily be made. Likewise longer rotations which include a greater variation in crops may be used in a strip-cropping plan. The important point to consider is that a thick-growing crop should be placed as often as possible below the strips of row crops.

Figure 15.


ORTH DAKOTA
MINNESOTA
M I C H
WISCONSIN
N
OUTH DAKOTA
IOWA
NEBRASKA
CORN
BELT
OHIO
ILLINOIS
INDIANA
KANSAS
MISSOURI

FIGURE 16.—In this field, alternate strips of a clean-cultivated crop and a close-growing crop are placed across the slope on the contour. Soil carried off the cultivated strips is caught by the strips of close-growing vegetation below.

FIGURE 17.—Alternate strips of corn and meadow across the slope on the contour help to prevent soil and water losses.

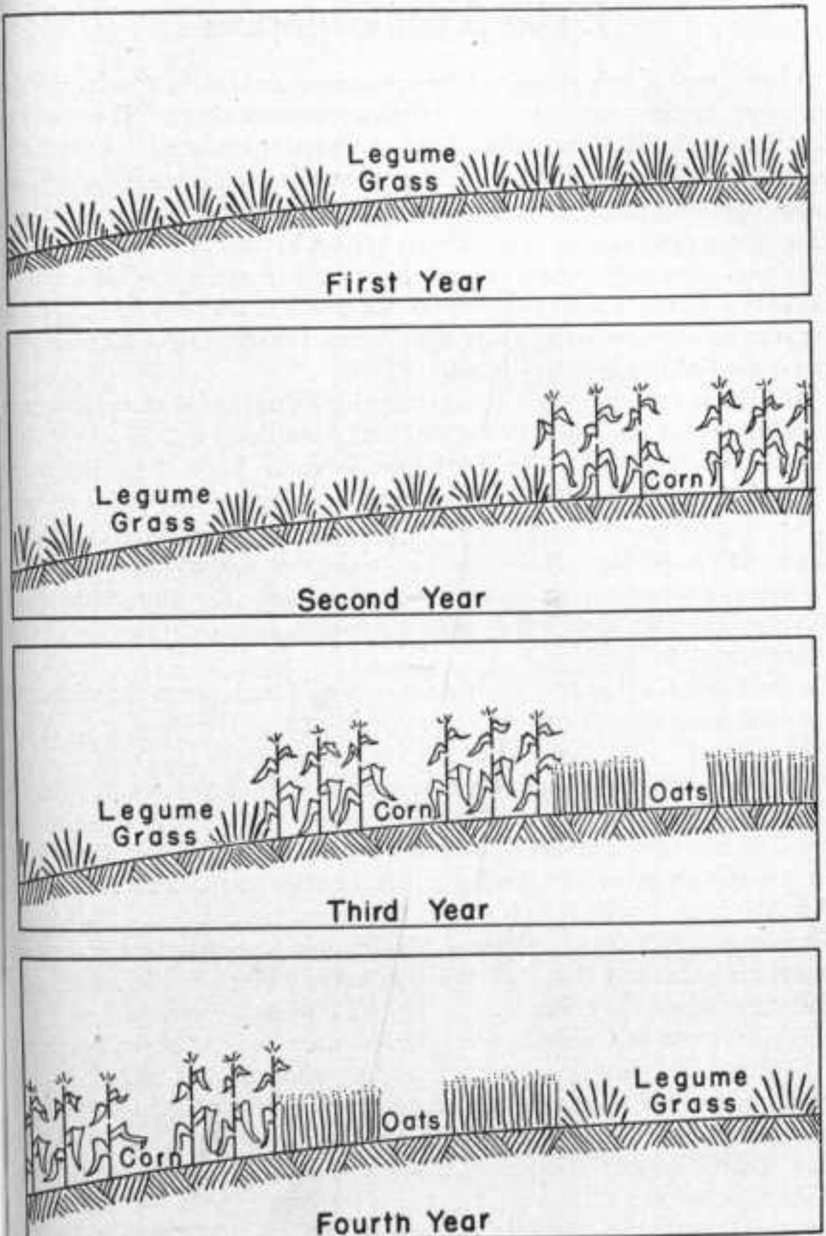


FIGURE 18.—How strip cropping may be started in a field.

Buffer-Strip Cropping

A buffer type of strip cropping is often recommended where certain objections are raised to the rotation type of cropping discussed above. The objections most frequently heard, are: Difficulty in pasturing the aftermath of strips cut for hay, chinch-bug infestation where small-grain and corn strips are adjacent, grasshopper attacks when corn is adjacent to small grain and grass, and the possibility of increased damage to the corn crop from hot winds.

To meet these objections a buffer type of strip cropping is often employed. Under this plan corn and small grain are not grown in the same field during any one year, and the percentage of the field in grass is much smaller than would be true in a rotation strip-cropped field.

To describe the buffer type of strip cropping let us assume that a farmer has three fields on which he grows corn, oats, and grass (clover and timothy) in rotation. Normally the sod is all plowed down for corn. But if the farmer wishes to have buffer strips to prevent soil washing, he will plow wide strips of sod on the contour for corn, leaving narrow strips of varying width which will be left permanently in meadow. If there is a natural draw or watercourse in the field he will leave a wide strip to serve as a grassed waterway. The buffer strips should seldom be less than 18 to 20 feet wide and should, as often as possible, extend entirely across the field.

In the spring of the second year the farmer would seed oats on the wide strips that were previously devoted to corn. Grass seed would be sown in the oat strips.

In the third year the entire field would again be in a hay crop. This same plan may be followed in the other two fields. In this way the farmer would use his normal rotation, and at the same time secure much of the benefits of strip cropping.

It is frequently possible and desirable to leave strips that are uniform in width. When this is done, point rows in row-crop strips are avoided.

Strip cropping, both the rotation and buffer type, has marked possibilities for erosion control in the Corn Belt. It is cheap and effective. There are some disadvantages, but the advantages far outweigh the disadvantages.

A dairy farmer in Ohio who has his whole farm under strip cropping says that he has solved the only serious problem in putting the plan into effect. The problem he referred to was the difficulty of pasturing the meadow strips. During the summer of 1936 he enclosed the meadow strips with a temporary wire fence. Low-voltage electric current was passed through one wire of the fence, and he reports that his cows never attempted to cross over to the strips where they were not wanted. During the winter of 1936 and 1937, 4-foot stakes, 3 by 3 inches, were prepared which are to be used exclusively to enclose the meadow strips as they occur each year in the rotation.

Strip Cropping on Terraced Land

Assuming that a farmer has a terraced field in clover sod that he expects to plant to corn; how can he benefit by strip cropping? The logical procedure is to avoid plowing the comparatively small irregular sod strips in the middle of the terrace intervals. These strips would be left for hay, and both the crop and stubble would check soil loss. Corn would be planted in full length rows parallel to and on each side of the terrace ridges, point rows thus being avoided. The proportion of the field which is planted to corn may be governed to some extent by the anticipated need for hay.

If the clover stand is not promising, the farmer may wish to plow the entire field. In this event the irregular areas in the middle of the terrace intervals may be seeded to an annual close-growing crop such as Sudan grass or oats. Corn would be planted in the same way as explained above. This method eliminates the necessity for cultivating point rows and likewise will provide a hay or seed crop from the irregular strips if soybeans or oats are seeded. Since oats must be seeded before corn can be planted, it would be necessary to determine in advance the exact position of the irregular strips of oats. Otherwise it would be impossible to avoid having point rows of corn.

Best results from strip cropping may be obtained when crops are rotated from strip to strip. A good crop rotation in itself reduces erosion, but the protection is enhanced many times by combining rotation with strip cropping.

FIGURE 19.—A silt deposit has destroyed the stand of corn in the natural waterway of this field. If the uplands had been protected from washing and if a wide grassed waterway had been provided in the draw most of the soil and water loss would have been prevented.

Grassed Waterways

Many fields in the Corn Belt may be given protection against erosion if grassed waterways are provided for all major depressions (fig. 19). In fields being strip-cropped or on fields contour-farmed without strip cropping, it is very essential that these depressions and natural waterways be seeded and left permanently in grass. Terracing, which is discussed on page 36, always provides facilities in the form of terrace outlets for carrying water safely off the land after it has left the terrace channels of the field. It is just as important to provide these facilities on fields which are being strip-cropped, and on a strip-cropped field the grass waterway serves the same purpose as terrace outlets on terraced fields.

In the natural waterways already scarred by erosion it may be necessary to place temporary structures such as sod strips or sod bags crosswise of the channel to get the waterway stabilized. The waterway should be seeded to a width ranging from 20 feet up to 100 feet, depending upon the amount of water to be carried and the steepness of the slopes on either side of the draw. It is especially desirable to have the grass strip extend well back on the shoulders of the waterway to prevent undercutting and gullying (fig. 20).

Seeded waterways should always be crossed at right angles with plows or cultivators, and these implements should be raised out of the ground at the edge of the strip to avoid destroying the sod. One should never plow parallel to the grass strip to give it a more trim appearance or for other reasons. To do so may start two more gullies.

Grassed waterways should not be considered wasteland. In addition to preventing the formation of gullies, they provide convenient turning places and often produce some of the highest yields of hay on the farm.

Cover Crops

A cover crop provides an "overcoat" for land that otherwise would lie bare and be subject to erosion during the greater part of the year. Bare, rolling land is particularly vulnerable to erosion if the season is open or devoid of heavy snowfall or deep freezing. The extent of loss will also depend upon the intensity and frequency of fall and spring rains. If the cropping system on rolling land does not provide for a small-grain or another thick-growing crop following corn or soybeans, a cover crop should be grown. Land thus protected will go well armed into battle with erosional forces during the time it is not occupied with a row crop.

Among the small grains (fig. 21) the cover crops best adapted to wide areas in the Corn Belt are rye, winter wheat, and winter barley. Among the legumes, the common clovers and vetch have been used most frequently. In more southern areas Korean lespedeza has proved useful.

FIGURE 20.—Widely grassed waterways in the natural draws of a field provide a cheap and effective method of preventing soil loss.

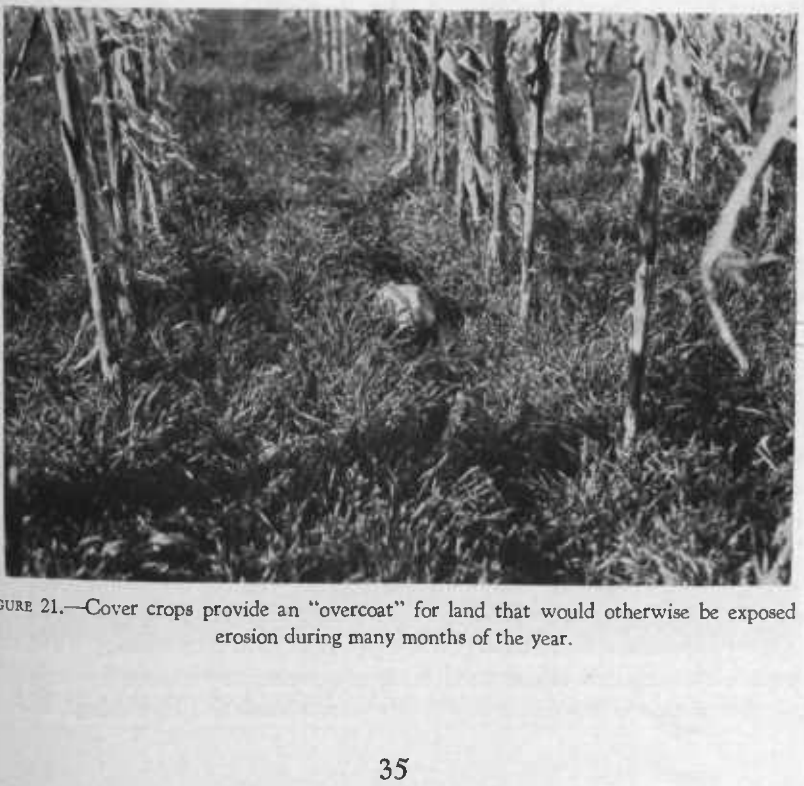


FIGURE 21.—Cover crops provide an "overcoat" for land that would otherwise be exposed to erosion during many months of the year.

Rye has been favored as a cover crop since it is hardy and perhaps better adapted to lands of low fertility than the other small grains. On better land, wheat or barley has given good cover. All of these grains if sown fairly early provide fall and spring pasture. Rye, however, is often pastured in the fall and then turned under for a green-manure crop in the spring, prior to corn planting.

If the stand and growth of clovers is sufficient, a cover crop is provided the first winter after seeding. Korean lespedeza, where adapted, will provide a fair cover even though the plants are killed after the first heavy freeze. This is true only if the stand is thick and the crop has not been cut for seed or pastured too closely. All legume cover crops supply protein feed if grazed, and are soil builders if properly handled.

Terraces

Of all the methods of saving soil, terracing probably has been the most widely tested. Over wide areas in the overcropped Southeast, where soil-laden rivers for 100 years have been running red to the sea, farmers developed the first "catch as catch can" methods of soil defense; and terracing was their chief reliance.

Their first puny earth ridges, often built with crude tools drawn by an 800-pound mule, evolved, as time went on, into the terrace of today. Priestly Mangum, a North Carolina farmer, and more recently M. L. Nichols, formerly of the Alabama Polytechnic Institute, developed the broad-base types of terraces, which today bear their names.

These new terrace types, perfected and improved in the South, have of late years been seen north of the Mason and Dixon line, where they have been further adapted to meet local needs. On land adapted to their use in Corn Belt Soil Conservation Service project areas, these improved terraces are among the modern soil- and water-saving devices. Yet even with the most recent improvements made possible in terrace construction by engineering skill, mechanical power, and more adequate equipment, terraces are considered as supplementary to other control measures. A terrace is but one weapon of defense in the modern elastic combinations of soil-saving strategy. Terraces should be used with crop rotations, contour farming, strip cropping, and other measures of defense that are most appropriate for a given field.

The success of one measure of defense depends upon that of another. Often a good cropping system will fail without the support given by mechanical measures. Again, terraces are almost sure to fail without the support of a proper cropping system, soil treatment, cultural practices, and maintenance. Terracing is especially important where the land is not covered by a crop, for it must be remembered that if terraces are properly constructed and maintained, they re-

main on the land indefinitely. Since many fields in the Corn Belt are without adequate vegetation during the periods of normally heavy rainfall, terracing offers additional insurance against soil and water loss. Terraces should not be used with the expectation that they will hold the soil so that the field may be cropped year after year to a cultivated crop like corn.

Terraces are earth ridges or intercepting channels built approximately on the contour from the soil of the field itself (fig. 22). Erosion-control measures, terracing included, depend, in the main, upon reducing the speed and volume of water as it flows down the slope of the land. On long slopes, even if gentle, flowing water picks up speed and volume. Fast-moving water breaks loose and carries away more soil than does slow-moving water. Properly constructed terraces break the long slope of a field into numerous short slopes. Surplus water accumulating in the terrace channel above the embankment is conducted slowly but safely off the field into a properly prepared terrace outlet (fig. 23).

Usually, terraces should not be constructed in cultivated fields which have steep slopes. No rule-of-thumb figures on the percentage of slope are appropriate because much depends upon the type of soil, relief of watershed, farming methods, and the crops grown. The maximum slope on which terraces may be used satisfactorily generally varies from 8 to 12 percent. If steeper slopes are terraced it frequently requires too much expense to maintain the ridges. Unless proper cropping and cultural practices are strictly adhered to, there is likely to be considerable erosion between the terraces.

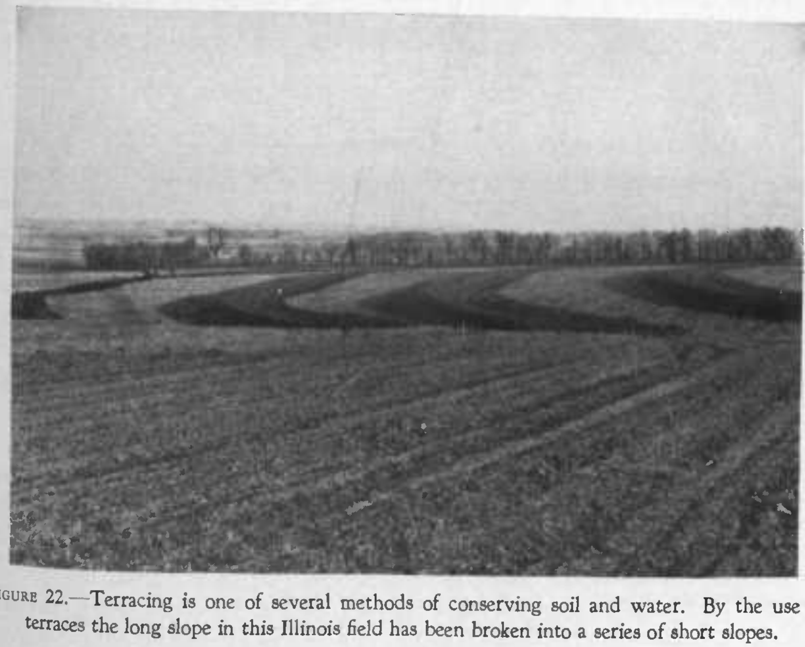


Figure 22.—Terracing is one of several methods of conserving soil and water. By the use of terraces the long slope in this Illinois field has been broken into a series of short slopes.

Variable Grades

On most Corn Belt soils the grade of a terrace should never exceed 4 inches in each 100 feet, and a variable grade is preferred. The grade is reduced at about 300-foot intervals from the outlet toward the upper end.

FIGURE 23.—Surplus water accumulating in the terrace channels above the embankments is conducted slowly, and therefore safely, off the field. The terrace system shown above, after a heavy rain, is the same as that shown in figure 22.

Spacing of Terraces

The spacing between terraces varies with the slope and, to a limited extent, with the soil type, the extent of erosion, and the rainfall. Table 2 may be used as a guide in determining the spacing of terraces on different slopes. These spacings are based on the original investigations of C. E. Ramser.

TABLE 2.—*Terrace spacings on land of the slopes indicated*

Item	Terrace spacings on land that has a slope per 100 feet of—				
	2 feet	4 feet	6 feet	8 feet	10 feet
	Feet	*Feet*	*Feet*	*Feet*	*Feet*
Vertical fall between terraces	2¾	3½	4	4¾	5½
Distance between terraces	137	88	67	59	55

Adequate Outlets

In numerous instances inadequate terrace outlets have caused the ruin of more land than the terrace embankments have saved. On the Soil Conservation Service project areas no terrace system is considered complete until means have been provided for conducting the excess water safely into stabilized natural drainage channels (figs. 24 and 25). Too often this water has been dumped onto steep slopes, into narrow ditches, and onto areas unprotected by a sufficient sod cover. Likewise, in many places the failure to maintain outlets after they have been properly constructed has led to trouble.

Prepare Outlets First

Where vegetated outlets are to be used, experience has shown that it is desirable to construct the outlets and get the sod firmly established before terraces are constructed on the field. If this is not done, it is sometimes advantageous to divert the water temporarily so that the sod in the outlet may become adequately established. These sodded outlets should have wide, flat bottoms ranging from 8 to 20 feet in width. If they are constructed in this way the water flow is spread and the cutting action of the water reduced. Engineering advice should be secured for the detailed design and location of any outlet before construction work is started.

When it is necessary to provide an outlet within the field being terraced, a wide grassed waterway (fig. 20) is a most desirable method of conducting water off the field.

Mechanical Outlet Structures

Terrace outlets which drain large areas or are situated where adequate vegetation cannot be developed may require a permanent structure of masonry or of concrete. These structures should be installed to provide definite grades; have adequate openings for water flow, as well as ample cut-offs and extension head walls to prevent overtopping or undermining. Other construction details are important for satisfactory results, and since structures of this type usually represent considerable cash outlay competent engineering advice should be obtained.

Maintenance of Terrace Systems

Terrace systems may be kept in good condition if proper tillage practices are followed and needed repairs are promptly made. If this is not done, the benefits which terracing would otherwise give, as well as the investment in the construction, will soon be lost. It is especially important that terraces be given considerable attention during the first year, when the ridges are settling. After each heavy rain any small breaks may be repaired quickly with a shovel before serious damage is done. Outlet channels likewise should be carefully watched

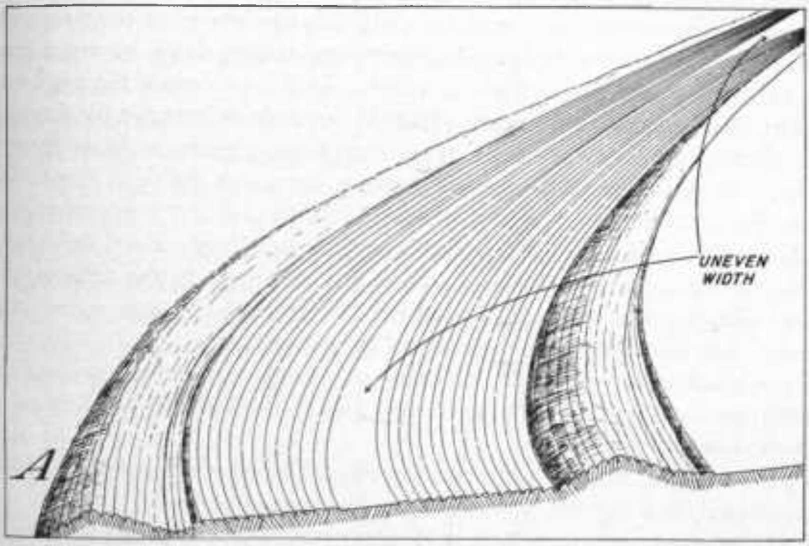
FIGURE 24.—Three terrace channels discharge surplus water into this well-vegetated outlet.

FIGURE 25.—Burlap strips have been placed across the waterway of this terrace outlet. These strips protect seedings and help to prevent washing until vegetation becomes established.

so that any damage from serious washing may be averted. Sod strips may be laid in small gullies that start cutting in the outlet. Any breaks or leaks around permanent structures should be filled and tamped before they become serious.

Plowing Terraced Land

Under most conditions terraced land should be plowed on the contour. Otherwise extra care and heavy maintenance costs are necessary.



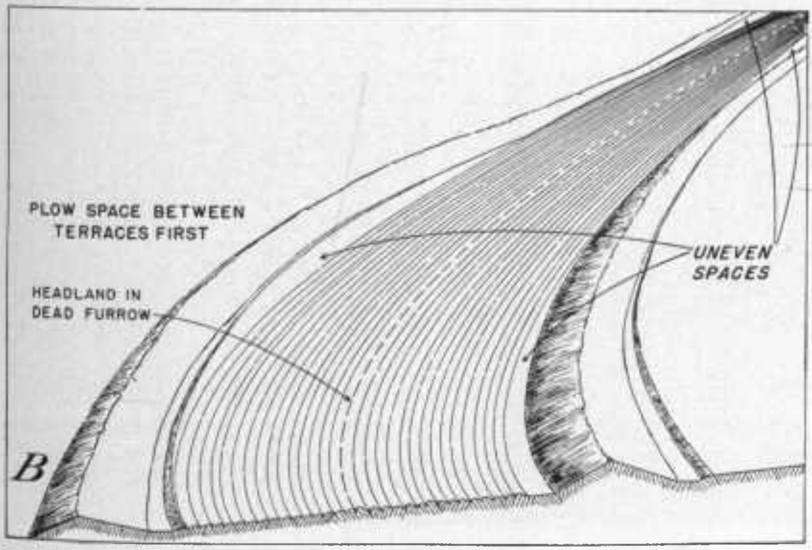


FIGURE 26.—A suggested method of plowing terraced land: A, First plowing; B, second plowing.

It is a simple matter to plow terraced land where terraces are an equal distance apart. Few fields, however, permit the uniform spacing of terraces, and herein lies the problem of plowing terraced land. This problem should be considered before terraces are constructed on a field.

The terrace itself is always plowed by throwing the furrow slice toward the center of the ridge. This broadens and raises the height of the terrace ridge, facilitating the operation of farm machinery. With the broad-base type of terrace this normally requires about six to eight furrows on each side of the ridge. The first time a terraced field is plowed the usual practice is to plow the terraces as described above, then plow out the intervening uneven strip, leaving a dead furrow midway between the terrace ridges. In this procedure the small and uneven areas, requiring turning, will likewise fall midway between the terraces.

In plowing the field the second time, some farmers prefer to plow the area between terraces first. This time, plowing is started in the dead furrow left when the terraced field was first plowed. In this case the strips of uneven width would lie adjacent to the terrace base of the uphill terrace and the channel of the terrace below. Since these uneven strips lie next to the terraces, and considerable turning is required, some farmers feel that the terrace channel is damaged less by trampling if the terraces are plowed last.

When the field is plowed the third time after being terraced the procedure is exactly the same as it was the first time. Figure 26 illustrates one method of plowing a terraced field.

Two-way plows eliminate some of the difficulties in plowing terraced land; comparatively few farmers, however, have this type of plow.

In more recent developments in Southern States, where terracing has been in use for many years, the modern practice is to do away with ridges and develop the water channels by plowing out. With this type of development, terraces on gentle slopes may be crossed with modern equipment and thus point rows may be eliminated. These rows are run, in many cases, approximately on the contour, being laid out from a convenient terrace.

Gully Treatment

Gullies are one of the results of erosion. If the cause of accelerated erosion can be removed or checked, fewer gullies will appear on the landscape. Gullies—the kind we usually notice—represent an advanced stage of erosion, but the cause lies back on the unprotected uplands. Preventing erosion—like the prevention of disease in medical practice—is cheaper than the cure.

If the appropriate methods of erosion control previously discussed are applied to cultivated land in the Corn Belt, fewer new gullies will appear. The old gullies, in turn, will be less active, thus giving nature a better opportunity to treat these wounds.

In the Corn Belt as elsewhere, gullies are ruining good land so swiftly that both preventive measures and remedial treatment are needed to check the soil and water loss. Something more adequate than just throwing things into gullies is required.

Prompt action against incipient gullies will save many fields (fig. 27). Several methods may be used. The sod-bag dam has proved effective and the expense is very low. Old bags (fertilizer or feed bags, usually) are partly filled with grass sod and imbedded in the bottom of washes. The sod is cut in small pieces, leaving as much soils as will cling to the roots. Soon the grass starts growing through the meshes of the bag, forming a dense sod. A grass-seed mixture is sown in the waterway between the dams. Rains deposit silt on the spreading grass above the dam, but the grass grows up through the new layer, and the wash

Figure 27.—Prompt action in checking incipient gullies will save many fields.

gradually fills. A succession of these sod-bag dams along the wash will help to stabilize the gully and hold soil on the field.

The grassed waterway, more fully discussed on page 34, is an effective method of stabilizing the smaller gullies in cultivated fields. Frequently it is necessary to divert water temporarily so that the gullied area may be smoothed down and seeded.

Small gullies in pasture fields often may be effectively treated by constructing inexpensive dams of brush, loose rock, and other materials that may be at hand. These inexpensive dams serve two purposes: (1) To collect soil in which vegetation can get started; (2) to prevent washing until vegetation alone is adequate.

When a large ravenous gully threatens to gnaw its way farther and farther into good farm land considerable preparation is usually necessary before the area can be lashed down with vegetation. One of the most difficult problems is to keep water out of the gully while these preparations are under way. Frequently, it is necessary to construct a temporary diversion ditch to carry water around the gully head until adequate vegetation is established. The banks of the gully are in many cases too steep and ragged for vegetation to gain a foothold. Furthermore, the poor soil in the bottom of the gully is not favorable for vegetation. Steep banks and poor soil on the gully floor frequently make it necessary to slope the banks and in the same operation throw better soil to the bottom. Bulldozers pushed by a tractor have been used successfully in many instances. Dynamite has been used in some others.

A gully may require temporary structures of wire and posts, rocks, or logs, depending on the materials at hand. These temporary obstructions in the water path give grass, shrubs, and trees an opportunity to stabilize the gully permanently.

Occasionally the value of the land or the proximity of dwellings and roadways may make it feasible to use masonry construction in the larger gullies. These structures are costly, and for this reason competent engineering advice should be sought before expense is incurred.

A wide variety of vegetation is suitable for gully-control work in the Corn Belt (figs. 28 and 29). Bluegrass among the grasses and black locust among the tree species are old standbys that have proved their worth. On project areas of the Soil Conservation Service various other grasses such as brome, reed canary, and mixtures of various sorts are under trial. In addition to the black locust tree other species such as green ash, white ash, black walnut, white oak, red oak, bur oak, pines, and spruces are being used, although care is exercised to restrict the use of hardwoods, except locust, to the better situations.

Of all the trees suitable for gully control, the black locust offers several advantages on badly eroded slopes. Its extensive root system helps to bind the soil and reduces erosion damage. It is a legume, and thus it improves the soil by adding nitrogen. It promotes the growth of grass even on poor soils. This is perhaps the chief value of locust in controlling soil erosion. On fairly good

soil it grows rapidly enough to be used for fence posts in about 10 to 15 years. The chief disadvantage is its tendency to spread, but such spreading can be checked if trees of another species are set around a black-locust planting. Locust

FIGURE 28.—In the spring of 1930 this gully was planted to black locust on the banks and with a few willows on the bottom. Conifer trees were planted on the uplands and some ash on the alluvial soils. (See fig. 29.)

FIGURE 29.—In 1933 this gully (fig. 28) was stabilized by vegetation and it is no longer active.

with 26.88 inches of rain falling on land (Carrington loam) sloping 10 feet in each 100, they found no loss of soil and only 2.5-percent loss of the water which fell on ungrazed native prairie grass. On land almost rendered bare by close grazing (mixed bluestem and bluegrass) 15 percent of the water ran off, carrying with it over 5 tons of soil per acre.

More than a hundred years ago Thomas Jefferson discovered that contour furrows conserved water and that this additional water could be retained for the benefit of plants. This method has been used widely in the Southeast on cultivated land, but more recently it has been applied with marked success to sloping pasture lands. The furrows are usually made by an ordinary moleboard plow and are run as nearly on the contour as possible. These furrows catch rain water and hold it until it has time to be absorbed by the ground. A system of these furrows on a pasture slope reduces the run-off of water and thus provides more moisture for the grass (fig. 31).

Pasture furrowing is now being widely tested in project areas of the Soil Conservation Service in the Corn Belt. Soil Conservation Service and Civilian Conservation Corps workers at Salem, Ind., following two heavy rains in the summer of 1936, examined a contoured pasture field to determine the depth of moisture penetration. Three feet above the furrows they found that water had penetrated between 3 and 4 inches, in the bottom of the furrows 18 to 24 inches, and down the slope below the furrows, 16 to 18 inches.

Improving Present Woodlands

If properly handled, the farm woods provide an excellent means of conserving soil and water and thus help to prevent erosion. Soil is preserved in the farm woods, and cultivated fields at lower elevations are given some protection. Unfortunately the farm woodland is usually not in condition to conserve soil and moisture because it has been damaged by livestock and fire.

Livestock, in their effort to get some feed in the woods, eat sprouts, tree seedlings, and other undergrowth. The natural cover of litter and vegetation is disturbed and the soil is compacted by trampling, and thus the capacity of the woods to absorb water as it falls is reduced.

Fire, to even a greater extent, destroys vegetation and the forest litter. Since the farm woods provides little pasture, it follows that the very least that should be done is to keep out livestock and to prevent fire.

However, such measures alone may not be sufficient to insure that the wooded land, which without the trees frequently would be the most erodible part of the farm, will be retained by the owner in this form of erosion-preventing vegetation. Whether or not the land is kept in woods will depend in many cases on the amount of revenue the owner derives. While returns may be expected from almost any woods, if they are protected from grazing and fire, it is as true of a woods as of any other crop that more money can be made if the tree crop is

operated under the plan of management that will produce the highest quality of products in the greatest quantity in the shortest time.

How this can be done most advantageously depends upon the particular woods. For example, in some places the stand should be thinned, in others additional trees should be planted, and at times salvage cuttings should be made to remove undesirable trees that, through shading or in other ways, reduce growth of good trees. Most farm woods are in such a condition that they require a combination of methods for the best results.

FIGURE 32.—Project areas of the Soil Conservation Service make it possible for farmers to see how coordinated soil-husbandry methods may be applied to their own land.

Joined Forces to Hold Soil

IN THE CORN BELT, as elsewhere in the Nation, farmers now have an opportunity to see how various soil-husbandry methods may be applied on their own land (fig. 32). In the past, in some sections of the country single practices such as terracing or various methods of gully control have been applied to farm land. These practices have served as partial demonstrations, but nowhere, until comparatively recently, has it been possible for a farmer to observe the coordinated application of numerous appropriate measures to a whole watershed.

In 1933 the Soil Conservation Service was assigned the task of providing projects of a convincing size and scope to show these practices, singly and in their appropriate combinations. These project areas, chosen with the advice of experiment station and extension service officials, have been located on land typical of large agricultural regions. Whole watersheds were selected. Many of these watersheds embrace from 200 to 1,000 farms and cover from 20,000 to 150,000 acres of land. After an area had been selected, the farms of all cooperating owners within it were surveyed, to ascertain the extent of erosion, the cover, the slope of the fields, and the characteristics of the soil.

The results of these surveys, when assembled, provided the basic pattern for an erosion-control program for the entire area. They showed how much soil had been lost, but more to the point, they revealed how much topsoil remained on the land. After a control program for the area was drawn up, it was presented to farmers, who at the same time were invited to participate in it. Those who were interested signed a written cooperative agreement to follow definite erosion-control practices for 5 years. The Service, in turn, signed the pact, agreeing to provide certain technical and material assistance in carrying out the program.

Yet before a control program was finally completed for a particular farm, specialists, accompanied by the farmer, walked over each and every field. They talked matters over and together planned a 5-year program. A cropping plan was determined after they had fully considered the requirements for cash crops, forage, and pasture. Rotations were fitted to the soil type, slope, and climatic factors. Corn and soybeans, for example, were withdrawn from the steeper slopes. To these steeper slopes soil-binding crops such as legumes and small grains were assigned.

Fences were relocated so that contour farming and strip cropping could be used in harmony with the slope of the land. Badly eroded areas were retired to grass or to trees. In short, when the program was completed, a course of action for 5 years had been drawn which was designed to make effective use of appropriate soil- and water-saving devices. Two project areas and a single farm typical of each are briefly described in the following pages.

The West Tarkio River Project

Flowing a bit west of due south, the West Tarkio River winds its way through Page and Montgomery Counties, Iowa, and Atchison and Holt Counties, Mo., joining the greater waters of the Missouri River near Falls City, Nebr. Fingerlike when viewed from a map, this watershed of 102,000 acres (tucked in Iowa's southwest corner and Missouri's northwest) is typical of a large and fertile area of western Iowa and northwest Missouri.

This watershed was once covered with a dense growth of grasses and other native vegetation. Grasses were predominant save for the comparatively narrow timbered areas along streams. Even though settlers appeared as early as 1850, subsistence farming was the rule until the railroads had been pushed westward after the Civil War. As railroads crossed the prairie, more and more sod was turned up. Grain growing was on the march. By 1880 practically all of the land in the West Tarkio River area had been broken for agricultural crops. Sixty percent of the cultivated land devoted to corn and small-grain and hay crops has been used for corn alone for the last 50 years.

The rich, humus-laden soil encouraged excessive cropping of the land. Frequently fields were kept in corn year after year, until yields became low because of depleted fertility or an excessive amount of weed growth. These fields were then seeded to grass crops and retired to pasture for 2 to 5 years. Following this brief period of "rest", the sod was again broken for continuous cropping to corn. Yet grass crops became more and more difficult to obtain because of excessive cropping to corn. In more recent years a few farmers have been replacing the grass forage crops with the deeper rooted legumes such as alfalfa and sweetclover.

When the West Tarkio project area was mapped in 1934 soil specialists estimated that the original topsoil was at least 20 inches deep. They drew this conclusion after examining soil profiles in old churchyards, schoolyards, and in other places that showed no evidence of cultivation. The remaining topsoil on the cultivated land, they found, averaged about 10 inches. So, despite a punishing type of agriculture and erosional losses, the potential fertility of the area is still very high.

When the results of the survey were presented to farmers, 433 of them operating 70,438 acres, signed cooperative agreements providing for the employment of more improved cropping practices, along with other erosion-control

methods. In 1934 these 70,438 acres were used as shown in the first column of table 3. Three years later, in 1936, these same acres were used to the extent shown in the last column of the table.

TABLE 3.—*Percentage distribution of land use on 70,436 acres in the West Tarkio River project when placed under cooperative agreements in 1934 and 2 years later*

Land use	Distribution of land use in—	
	1934	1936
	Percent	Percent
Clean-tilled crops (principally corn)	48.0	36.4
Small grains	17.0	21.7
Legumes	16.8	23.0
Pasture	11.8	12.5
Roads, buildings, and lots	6.4	6.4
Total	100.0	100.0

Of the more than 70,000 acres, belonging to these 433 farmers, 20,299 acres were tilled on the contour for the first time during this 3-year period. Strip cropping was used on 1,700 acres. Approved rotations were employed on less than 10,000 acres in 1934. Satisfactory rotations are now established on 37,000 acres. Winter cover crops are now being grown on 2,615 acres for the first time. To insure legume growth, lime was applied on 12,849 acres and phosphorus on 2,774 acres. Terraces totaling 140 miles in length have been constructed, and over 5,000 temporary gully dams have been installed. Trees were planted on gullied areas totaling 197 acres.

During the 3-year period 7,844 farmers visited this area to see the soil- and water-conservation measures being employed.

One Man's Land

A 160-acre farm (fig. 33) lost less soil than many others in the West Tarkio watershed where soil- and water-saving operations were started in late April 1934. Years of rather definite crop rotation—corn, oats, and clover with 12 to 20 acres of alfalfa—had left the land in apparently good condition. Yet as planes whirred overhead getting bird's-eye pictures for air maps, soils men on the ground estimated that between 50 and 75 percent of the topsoil was gone. They noted that the slopes were so steep (a 7-percent average for the whole farm) that despite better than average care in the past, too much topsoil was leaving the land.

Gullies etched the earth deeply on the west side of the farm where slopes dropped away about 10 feet for each 100 in distance. Here the owner had

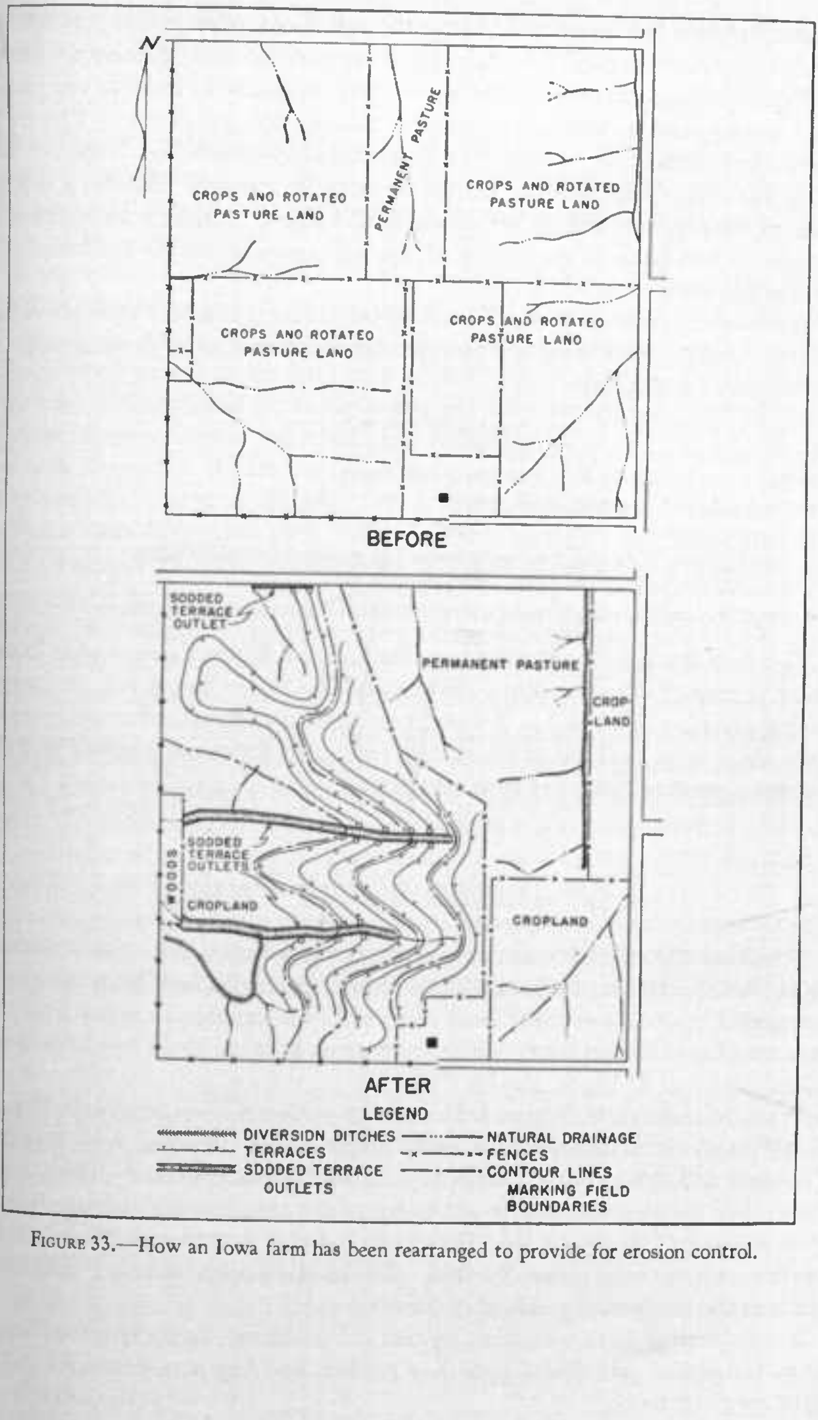


Figure 33.—How an Iowa farm has been rearranged to provide for erosion control.

planted trees a few years ago to stay the soil losses. But gullies had not yet eaten heavily of this farm, for when the owner made a 5-year agreement with the Soil Conservation Service in 1934 it was only necessary to increase the permanent woods planting from 1.5 to 5 acres. Save for the retirement of 30 acres to permanent pasture and excluding the area occupied by roads, buildings, and lots, all of the other acres will be devoted to crops in rotation. Alfalfa, a definite crop in the rotation, will be left on the land 4 years. Alfalfa is to be followed by one or two crops of corn. The alfalfa will again be seeded in a nurse crop of oats following corn.

The essential problem on this farm is to keep the soil in a high state of productivity. Looking back over a 3-year period we detect the following steps in developing soil defenses:

1. Retired steeper land to pasture and to farm woods.
2. Planted more trees in gullied area.
3. Seeded waterways for terrace outlets in fall of 1934.
4. Terraced northwest field in fall of 1935.
5. Terraced southwest fields in fall of 1936.
6. Divided fields on contour lines using terraces as guides to contour farming.
7. Established crop rotations in the new pattern of field lay-out.
8. Limed 91 acres (2 tons ground limestone per acre) to help insure legume stands.

This farm lies less than 2 miles from the Soil and Water Conservation Experiment Station at Clarinda, Iowa. When one checks the list of soil- and water-saving practices employed in 3 years' time against the measurements obtained from these same methods at the station farm, it is logical to conclude that the greater portion of losses has been averted.

The Indian Creek Project

Touching the rolling border line of Ohio and Indiana, one county removed from the Ohio River, the Indian Creek project of the Buckeye State embraces a watershed of 30,144 acres of land. Indian Creek carries the water from this area into Great Miami River where it moves southward but a few miles to the Ohio.

When Mad Anthony Wayne led his plucky pioneer soldiers into Butler County in 1792 and 1793, they found a broad fertile valley carpeted with luxuriant bluegrass and the hills and ridges beyond in hardwood timber. Thirty years later, after the almost complete settlement of the area, livestock farming became prominent, for Cincinnati, the "Porkopolis" of that day, provided a convenient market. Grains were grown for feed. To this day hogs have held an important place in the livestock population of the area.

Hogs gave way in time to other agricultural products. In the horse-and-buggy days Cincinnati provided a good hay market, and hay was grown for a cash crop on many farms.

Wheat acreage, during World War years, was pushed up on slopes that had never been broken by the plow. After the war, declining prices for grain and prospering industrial cities brought an increasing number of dairy cows to these Ohio farms.

At the present time the percentage of receipts for the 195 farms in the area is divided approximately as follows: Livestock and livestock products, 76 percent; crops, 13 percent; and miscellaneous items, including returns from farm woods, 11 percent.

The uplands are gently rolling, with broad long slopes. These long, easy slopes, many of them from three-quarters to a mile in length, extend downward to short abrupt breaks above comparatively broad level bottom land.

The original topsoil in the area was from 12 to 14 inches in depth. Good crops were common until the fertility was partially depleted, the soil washed, and clover failures became more and more numerous. Clover failures were due in part to drought, to depletion of lime in the surface soil, and to the decreased water-holding capacity of the soil. With clover failing, hay became scarcer, more acres were devoted to corn, and livestock was forced on pastures too early in the spring and left there too late in the fall, with the result that pastures have deteriorated rapidly.

Because of inadequate vegetative cover on crop, meadow, farm woods, and pasture land, soil losses have mounted perceptibly during the last few years. Sheet washing has caused the greatest losses, and gullies, though not so numerous or so large as in many other areas, have become more and more troublesome.

The area was surveyed in the fall of 1935. Conservation specialists estimated that from 50 to 75 percent of the surface soil on the uplands had been washed away. This means that over most of the area farmers now have less than 7 inches of topsoil upon which to farm, as compared with the 14 inches which originally covered the land slightly more than 100 years ago.

On well-handled land the survey revealed less soil loss than on land poorly managed. On well-managed land sloping 3 feet or less in each 100, the loss was usually not more than 25 percent. On some slopes of 12 percent or more, even with good soil management, all of the surface soil had been removed. Even on 3-percent slopes where good management had not been practiced a 50-percent loss of topsoil was not uncommon. On still steeper slopes (8 to 12 percent), under inferior management, soil losses were between 75 and 100 percent.

Control measures in use on the Indian Creek watershed represent for the most part a concerted development of proven devices to hold soil. The first step is to retire from tillage the most erodible slopes. Slopes less vulnerable, if they must be tilled for the sake of income, are given the benefit of every adaptable soil-holding device such as contour farming, strip cropping, and terracing when necessary. In general, slopes above 20 percent are reforested, slopes of about 15 percent are kept permanently in sod, while lowlands and gentler slopes are strip-cropped on the contour with a soil-conserving rotation that requires as little plowing as possible.

Pasturing of woodlands, which provide little or no feed, and overgrazing of pastures are responsible for much of the trouble. Hence, pasture improvement is emphasized both as a control measure and as a way to increase farm income. Livestock, in turn, is fenced out of woodlands, thus giving the natural reproductive undergrowth an opportunity to survive. On rough or gullied areas trees and shrub plantings are provided to benefit wildlife.

It takes time, as every farmer knows, to readjust cropping programs on a farm. To alter the pattern of field lay-out, to change fences to conform to the lay of the land, and to adjust the cropping sequence usually involves from 1 to 5 or more years. Even though conservation measures were not begun until the spring of 1936—the first agreement was signed October 19, 1935—87 farmers operating 10,628 acres in the Indian Creek area made changes in land use as shown in table 5.

TABLE 5.—*Land use on 10,628 acres in the Indian Creek area when placed under cooperative agreements in 1935 and in 1936*

Land use	Distribution of land use in—	
	1935	1936
	Percent	*Percent*
Corn	21. 7	16. 6
Small grain	17. 4	15. 1
Rotation meadows	18. 0	19. 0
Miscellaneous cropland	5. 0	3. 1
Permanent meadows	. 5	6. 4
Permanent pasture (open)	27. 6	29. 3
Permanent pasture (wooded)	4. 3	. 2
Woodland (protected)	1. 2	6. 5
Idle, waste, and unproductive	4. 3	3. 8
Total	100. 0	100. 0

An Ohio Farm

The 151 acres in the Ohio dairy farm (fig. 34) lie on long slopes. From the highest point on the western border, where the buildings stand, these slopes extend the entire length of the farm (about 3,000 feet) terminating at Four Mile Creek near the eastern boundary. These slopes are not steep. They average about a 3-foot drop in each 100 feet for the entire farm, varying from about 1 percent near the buildings to 5 percent or more nearer the stream.

In the past, a well-managed cropping system and liberal applications of manure have prevented more erosion on this farm than would otherwise have occurred.

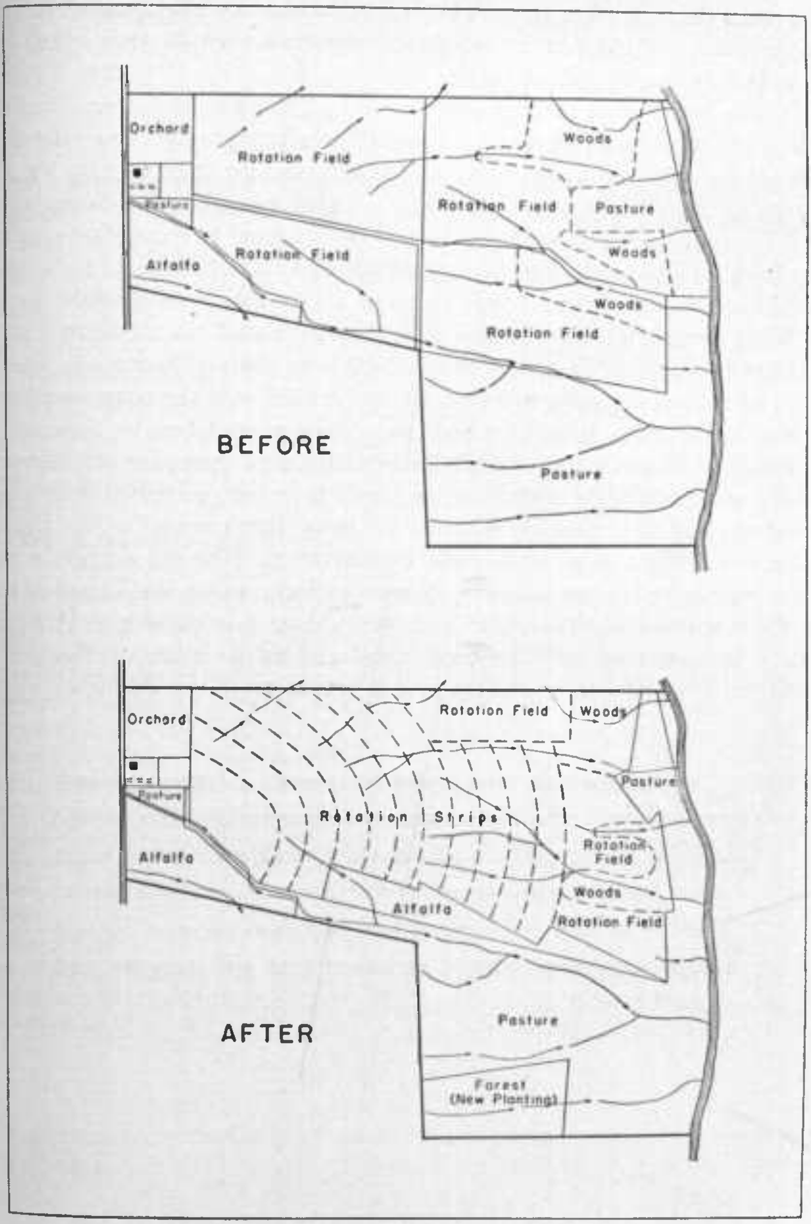


FIGURE 34.—How an Ohio dairy farm was rearranged to employ soil- and water-saving practices.

For years the owner has grown corn, wheat, clover, and alfalfa in well-balanced combinations. Furthermore, manure accumulations from 20 cows and 35 hogs have been promptly applied on the land.

Despite better than average care of this land the long slopes permitted rain water to attain a cutting speed. Thus soil was being carried down the slopes toward the east and gullies were continually working their way up the same slopes in the opposite direction. On the higher elevations the owner noticed that his plowshare was raising more and more subsoil to the surface each year the fields were plowed. He also noticed that about 2 feet of topsoil had accumulated along a fence which crossed the slope about midway of the farm (fig. 34).

When specialists surveyed this farm they estimated that between 6 and 7 inches of topsoil had been lost from the 87 acres devoted to crops in rotation.

By comparing the pattern of farm lay-out in 1935 with the rearranged plan in effect during 1936, it will be seen that steps were taken to conserve soil and water. Fences were relocated, broken cultivated areas have been retired to alfalfa and pasture, the woods on the south have been protected from grazing livestock, and approximately 80 acres are being strip-cropped on the contour. Lime was applied on all of the land in cultivation. The old rotation of corn, corn, wheat, and clover has been changed to corn, wheat, and clover on some of the strips and to corn, wheat, and sweetclover in other strips. Under this plan a green-manure crop has been introduced in the rotation. Furthermore with the new rotation none of the land is bare of vegetation during the winter.

Soil lost from the land cannot be returned. Nature can build new soil, but only with the tediousness of centuries. Our problem is to live on the good soil that remains, to defend it as we use it, and to leave it so that succeeding generations may also live upon it. There is no time for regret of past mistakes; we must appraise wisely our opportunities in the use of land and make the most of them.

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